Readme file for CU WindCube lidars in WFIP2

This readme file introduces the basics of the Doppler lidar data and gives a detailed description of the variables present in the data files. If you have any further questions about the data and its interpretation, please contact Julie Lundquist (Julie.Lundquist@colorado.edu). Please reach out to discuss any planned use of this data with Julie. If the use of this data in a publication constitutes a major or reasonably significant aspect of an article, co-authorship by Prof. Lundquist or a student in her group working with the data may be appropriate and should be discussed. We welcome collaborations and will cheerfully lend our scientific expertise in interpretation and evaluation of the data.

Instrument locations

The locations of the instruments during WFIP2 is described in Table 1. While instruments were first deployed on 20 Nov 2015, the Wasco unit had an instrument failure and did not collect good data until its repair and redeployment 23 Feb 2016. The Troutdale unit was removed on 22 Feb 2016, repaired, and redeployed 20 April 2016. (Troutdale data is fine from 20 Nov 2015-22 Feb 2016, but tends to have lower visibility.)

Location	Lidar Type (unit number)	DAP location label	Latitude	Longitude	Elevation (meters above sea level)
Troutdale	V1 (WC49)	z01	*45.55093052* **45.553418°**	*-122.4071554* **-122.386995°**	12
Gordons Ridge	V2 (WC231)	z02	*45.51640983* **45.515620°**	*-120.7757628* **-120.780007°**	728
Wasco	V1 (WC68)	z03	*45.59019596* **45.589999°**	*-120.6707262* **-120.672044°**	455

Table 1: List of instrument locations. The italicized latitudes and longitudes are from field measurements. The boldface latitudes and longitudes are measurements corrected by comparison to Google Earth images.

Instrument measurement approach

The Windcube profiling lidars sample line-of-sight (LOS) velocities sequentially in four cardinal directions along a nominally 28° azimuth from vertical, simultaneously sampling ten range gates centered on 40, 60, 80, 100, 120, 140,

160, 180, 200, and 220 m AGL. This approach assumes homogeneity for four seconds across the cone defined by the four beams; the resulting uncertainty can be quantified in complex terrain (Bingöl et al. 2009) and inhomogeneous flow (Rhodes and Lundquist 2013; Lundquist et al. 2015). Similarly, the v2 lidar samples LOS velocities in four cardinal directions along a nominally 28° azimuth from vertical, followed by a fifth, vertically-pointed beam to directly measure the vertical component of the flow.

Description of data files

The initial .nc files provided to the DAP are lightly post-processed .STA files which are automatically generated by the lidar software, providing 2-minute averages (time stamp at the end of the averaging period) of wind profiles. The variables are described below. These data should be sufficient for evaluation of mesoscale models. For more refined case studies, the 1-Hz data should be used. Before the end of the WFIP2 field campaign, please contact Julie Lundquist (Julie.Lundquist@colorado.edu) for access to the 1-Hz data, which will be provided to the DAP at the end of the campaign.

Within the .nc files provided to the DAP, u is the zonal component of the flow (positive from west to east), v is the meridional component of the flow (positive from south the north), and w is the vertical component of the flow (positive from down to up). Note that this is not the sign convention that Leosphere usually provides the .STA files in – we have post-processed the data.

The available variables are:

- Vhm: mean **scalar-averaged** horizontal wind speed (m s^{-1}) for the 2-min period
- dVh: standard deviation of **scalar-averaged** horizontal wind speed (m s^{-1})
- VhMax: maximum 1-sec wind speed measurement during the 2-minute period (m s^{-1})
- VhMin: minimum 1-sec wind speed measurement during the 2-minute

period (m s^{-1})

- Azim: vector-averaged wind direction (meteorological coordinates)
- um1: average u-component (m s^{-1})
- du1: standard deviation of u-component (m s^{-1})
- vm1: average v-component (m s^{-1})
- dv1: standard deviation of v-component (m s^{-1})
- wm1: average w-component (m s^{-1})
- dw1: standard deviation of w-component (m s^{-1})
- CNRm: average CNR for the two-minute period (dB);
- dCNR: standard deviation of CNR (dB)
- CNRmax: maximum CNR (dB)
- CNRmin: minimum CNR (dB)
- spectral_broadening: 2-minute-averaged spectral broadening (converted to m s^{-1})
- dspectral_broadening: standard deviation of spectral broadening (m s^{-1})
- Avail: percentage of data available at this altitude (assuming CNR threshold of -22 dB)

Quality control notes

Basic quality control, requiring that an individual line-of-sight (LOS) velocity be measured with a carrier-to-noise ratio greater than -22 dB, has already been applied to these data. The two-minute averages are based only on the 1-Hz LOS with CNR exceeding -22 dB. However, two-minute averages with “Avail” less than 90% should be considered suspicious. Lidars require a sufficient number of scatterers for a return signal, so clean air conditions have lower availability (Aitken et al. 2012).

Selected images of lidars in the field

The Troutdale system (z01 in the DAP) is located at the Troutdale Water Treatment facility with a number of other WFIP2 instruments operated by NOAA. Its context is shown in Figure 1 and Figure 2.

Figure 1: WC-49 located at Troutdale; photo facing south. The lidar is the white box at right. The NOAA radiometer is seen in the center of the image along with a surface met station center-left. Photo courtesy Rochelle Worsnop.

Figure 2: WC-49 located at Troutdale; photo facing west. The lidar is the white box at center. Photo courtesy Josh Aikens. (Students pictured, left to right, are Clara St. Martin, Rochelle Worsnop, and Joseph C.-Y. Lee.)

The Gordons Ridge system (z02 in the DAP) is located just southeast of the Lockheed Martin WindTracer lidar on Gordons Ridge. Its context on the ridge is shown in Figure 3 and Figure 4.

Figure 3: Context of WC-231 located at Gordons Ridge; photo facing west (sun is setting on 20 Nov 2015). The lidar is not shown. Photo courtesy Rochelle Worsnop.

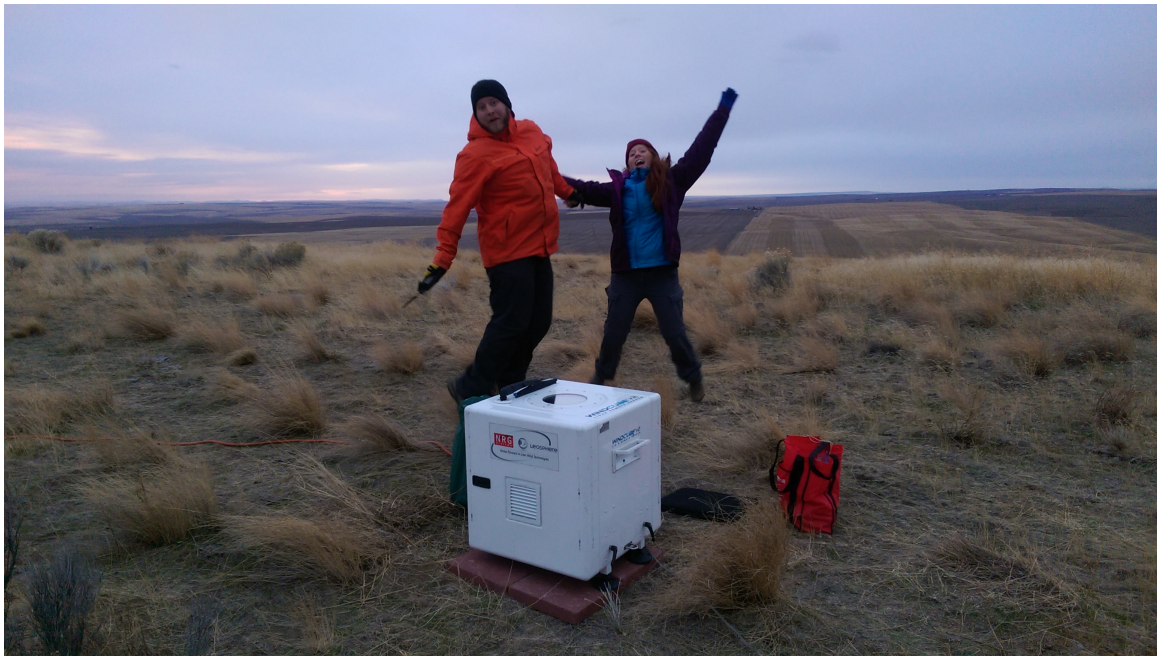

Figure 4: Context of WC-231 located at Gordon's Ridge; photo facing south-west. Students are Josh Aikens and Rochelle Worsnop. Photo courtesy Julie Lundquist.

The Wasco system (z03 in the DAP) is located at the west end of the runway at Wasco airport with several other instruments. Its context is shown in Figure 5 and Figure 6.

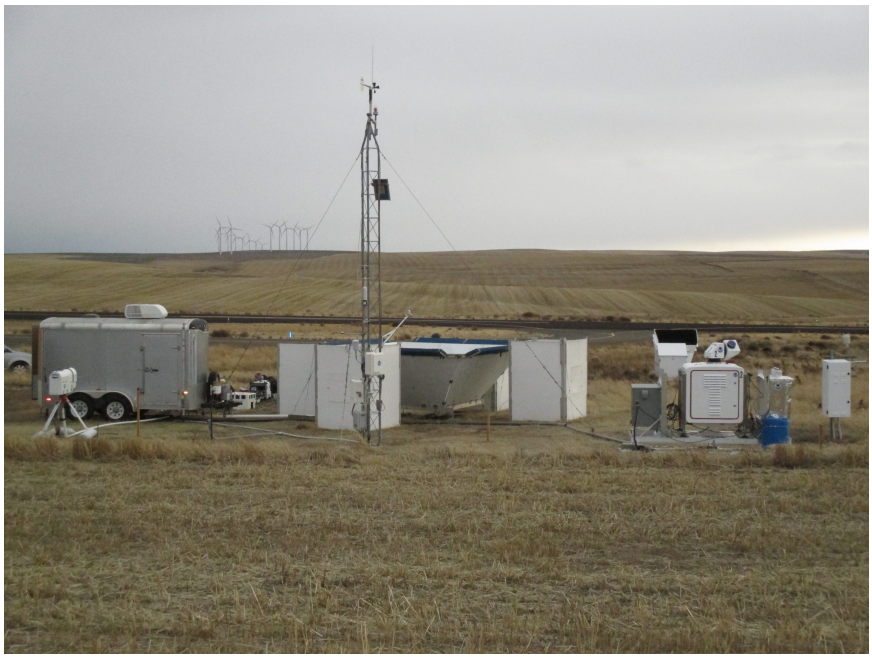

Figure 5: Context of WC-68 located at Wasco airport, view to the south. The lidar is at left, just to the right of the large silver trailer. Photo courtesy Laura Bianco.

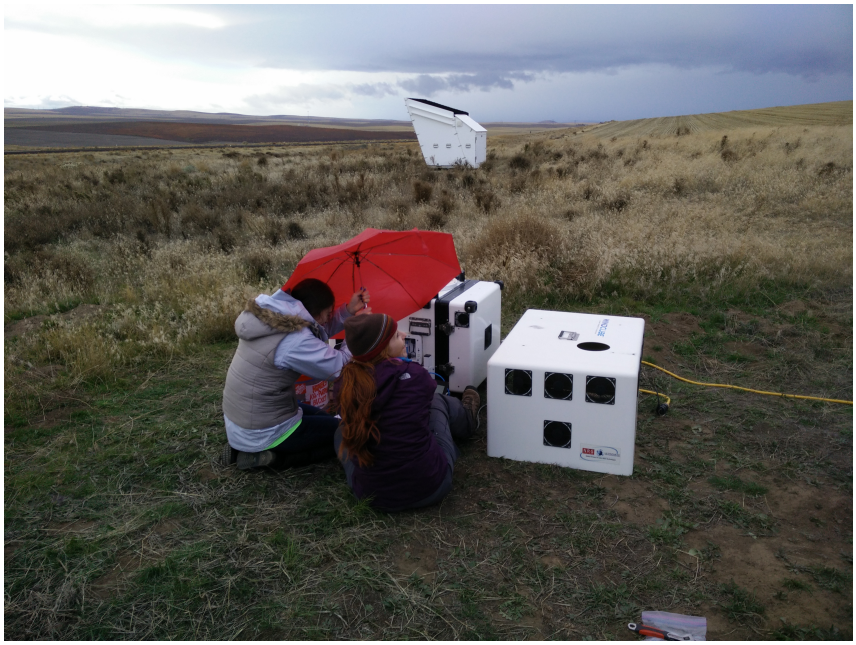

Figure 6: Context of WC-68 at Wasco, view to west-south-west. The lidar is located behind the two students shown here, with the lid to the right. Photo courtesy Joseph C.-Y. Lee.

References

Aitken, M. L., M. E. Rhodes, and J. K. Lundquist, 2012: Performance of a Wind-Profiling Lidar in the Region of Wind Turbine Rotor Disks. *J. Atmospheric Ocean. Technol.*, **29**, 347–355, doi:10.1175/JTECH-D-11-00033.1.

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